

WHAT IS CLAIMED IS:

1. In a communications system including a central communications station and at least one remote communications station, said central communications station having an antenna array for generating an antenna beam pattern used for transmission of information signals received by said remote communications station, a method for adaptively forming said beam pattern comprising the steps of:

statistically characterizing a receive channel vector, said receive channel vector being representative of a receive communications channel over which signal energy is transmitted from said at least one said remote communications station to said central communications station;

generating a beam pattern weight vector based on results of statistical characterization of said receive channel vector, said beam pattern weight vector being generated in accordance with a predetermined quality measurement of said information signals received by said remote communications station; and

forming said beam pattern using said beam pattern weight vector.

2. The method of claim 1 further including the step of estimating said receive channel vector using one or more time-varying channel estimation filters.

3. The method of claim 1 wherein said step of statistically characterizing further includes the step of compiling an estimated receive channel covariance matrix.

4. The method of claim 3 wherein said step of generating said beam pattern weight vector includes the step of time averaging said estimated receive channel covariance matrix in order to form an estimated transmit channel covariance matrix.

5. The method of claim 4 further including the step of using said estimated transmit channel covariance matrix to form objective and constraint functions from which said beam pattern weight vector is determined.

6. In a communications system including a central communications station and at

least one remote communications station, said central communications station having an antenna array for generating an antenna beam pattern used for transmission of information signals received by said remote communications station, a system for adaptively forming said beam pattern comprising:

means for statistically characterizing a receive channel vector, said receive channel vector being representative of a receive communications channel over which signal energy is transmitted from said at least one remote communications station to said central communications station;

means for generating a beam pattern weight vector based on results of statistical characterization of said receive channel vector, said beam pattern weight vector being generated in accordance with a predetermined quality measurement of said information signals received by said remote communications station; and

a beamforming network for forming said beam pattern using said beam pattern weight vector.

7. The system of claim 6 further including one or more time-varying channel estimation filters for estimating said receive channel vector.

8. The system of claim 6 wherein said means for statistically characterizing further include means for compiling an estimated receive channel covariance matrix.

9. The system of claim 8 wherein said means for generating said beam pattern weight vector includes means for averaging said estimated receive channel covariance matrix in order to form an estimated transmit channel covariance matrix.

10. The system of claim 9 further including means for using said estimated transmit channel covariance matrix to form objective and constraint functions, said beam pattern weight vector being obtained by solving said objective and constraint functions.

11. In a cellular communications system including a base station and at least one mobile unit, said base station having an antenna array for projecting a transmit antenna beam pattern used for transmission of information signals to said mobile unit, a system

for adaptively forming said transmit antenna beam pattern comprising:

a receive channel beamforming network for processing signal energy transmitted by said at least one mobile unit over a receive communications channel to said antenna array, said receive channel beamforming network including means for producing a statistical characterization of a receive channel vector wherein said receive channel vector is representative of said receive communications channel; and

a transmit channel beamforming network for generating a transmit beam pattern weight vector based on said statistical characterization, and for forming said transmit antenna beam pattern using said transmit beam pattern weight vector;

wherein said transmit beam pattern weight vector is generated so as to improve quality of signal reception within said mobile unit.

12. The system of claim 11 further including a diplexer connected between said antenna array and said transmit and receive channel beamforming networks.

13. The system of claim 11 wherein said receive channel beamforming network further includes:

means for generating a receive channel weight vector, and means for scaling signal energy received by antenna elements of said antenna array in accordance with said receive channel weight vector.

14. The system of claim 11 wherein said means for producing a statistical characterization of a receive channel vector further includes means for compiling an estimated receive channel covariance matrix.

15. The system of claim 14 wherein said transmit channel beamforming network includes:

means for averaging said estimated receive channel covariance matrix in order to form an estimated transmit channel covariance matrix, and

means for deriving said transmit beam pattern weight vector from said transmit channel covariance matrix.

16. The system of claim 15 wherein said means for deriving said transmit beam pattern weight vector includes means for determining the principal eigenvector of said transmit channel covariance matrix, said transmit beam pattern weight vector corresponding to said eigenvector of said transmit channel covariance matrix.

17. The system of claim 11 further including calibration means for calibrating said transmit and receive channel networks.

18. The system of claim 17 wherein said calibration means includes:  
means for applying a set of test signals to a corresponding set of output ports of elements of said antenna array, and  
means for measuring amplitude change and phase shift of each of said test signals arising due to propagation over receive channel paths within said receive channel network.

19. The system of claim 18 wherein said calibration means includes means for equalizing amplitude and phase response through said receive channel paths based on measured phase shift of said test signals.

20. The system of claim 17 wherein said calibration means includes:  
means for applying a set of test signals to said transmit channel network, and  
means for measuring amplitude change and phase shift of each of said test signals within said set of test signals arising due to propagation over transmit channel paths within said transmit channel network to a corresponding set of antenna elements of said antenna array.

21. The system of claim 20 wherein said calibration means includes means for equalizing amplitude and phase response through said transmit channel paths based on measured phase shift of said test signals.

22. In a cellular communications system including a base station and at least one mobile unit, said base station having transmit and receive antenna arrays for providing

transmit and receive antenna beam patterns, respectively, a system for adaptively forming said transmit antenna beam pattern comprising:

a receive channel beamforming network, operatively coupled to said receive antenna array, said receive channel beamforming network including means for producing a statistical characterization of a receive channel vector wherein said receive channel vector is representative of a receive communications channel over which information is transmitted from said at least one mobile unit; and

a transmit channel beamforming network, operatively coupled to said transmit antenna array, for generating a transmit beam pattern weight vector based on said statistical characterization and for forming said transmit antenna beam pattern using said transmit beam pattern weight vector.

23. The system of claim 22 wherein said means for producing a statistical characterization of a receive channel vector further includes means for compiling an estimated receive channel covariance matrix.

24. The system of claim 23 wherein said transmit channel beamforming network includes:

means for time-averaging said estimated receive channel covariance matrix in order to form an estimated transmit channel covariance matrix, and

means for deriving said transmit beam pattern weight vector from said transmit channel covariance matrix.

25. In a radio frequency communications system including a central communications station having an antenna array, a method for forming a transmit antenna beam pattern comprising the steps of:

adaptively beamforming a signal received from a remote communications unit in order to configure a receiver beam weighting network;

determining an estimated receive channel vector using said signal received from said remote communications unit, said estimated receive channel vector being determined at least partly in accordance with a beamformed signal generated by said receiver beam weighting network; and

transmitting a beamformed signal to said remote communications unit based upon said estimated receive channel vector.

26. The method of claim 25 wherein said step of transmitting further includes the step of averaging said estimated receive channel vector.

27. The method of claim 25 wherein one or more time-varying channel estimation filters are used to determine said estimated receive channel vector.

28. In a radio frequency communications system including a central communications station having an antenna array, a system for adaptively forming a transmit antenna beam pattern comprising:

means for adaptively beamforming a signal received from a communications unit in order to configure a receiver beam weighting network;

means for determining an estimated receive channel vector using said signal received from a communications unit, said estimated receive channel vector being determined at least partly in accordance with a beamformed signal generated by said receiver beam weighting network; and

a transmit beamforming network for transmitting a beamformed signal to said communications unit based upon said estimated receive channel vector.

29. The system of claim 28 wherein said transmit beamforming network includes means for averaging said estimated receive channel vector.

30. The system of claim 28 wherein said means for determining said receive channel vector includes one or more time-varying channel estimation filters.